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Evaluation of the GEOWEB and J.K. STRUCTURE Slope Stabilization Methods

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16. Abstract

In the fall of 1994, two different slope stabilization products (J.K. Structure manufactured by J.K. Structure of France and Geoweb Cellular Confinement System, manufactured by Presto Products Company of Appleton, WI.) were installed adjacent to State Trunk Highway 35 along the Mississippi River in west central Wisconsin in an effort to evaluate their effectiveness for erosion control and slope stabilization.

The natural slope of the talus material was approximately 1 1/4:1, but because of space constraints between the bluff and the Mississippi River, the back slopes were left at 3/4:1. The test site was 20 ft. - 30 ft. high and approximately 300 ft. long, so that each test section (the two products and the control area) was approximately 200 m^2.

After five years, the performance of these products was rated as better than the control area (no treatment), preventing small localized areas of erosion and major slope failures. However, due to costs and installation difficulties, these products were not recommended for widespread use in Wisconsin as the investment return was minimal. However, these products did perform satisfactorily enough so that they could be considered for use on a case by case basis where major slope failures are common.

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INTRODUCTION

In an effort to address and solve slope stability problems along State Trunk Highway 35 along the Mississippi River in west central Wisconsin, the Wisconsin Department of Transportation installed two different experimental slope stabilization systems in the fall of 1994. Due to space restrictions along the Mississippi River, some slopes were constructed at a ¾:1 slope (for each ¾ foot horizontally, there was a 1 foot vertical rise). These slopes, which consisted of talus material, have in the past experienced erosion, instability and lack of vegetation. Two products, J.K. Structure and Geoweb Cellular Confinement System, were installed to test their effectiveness as possible solutions to these problems. It was thought that if these tests proved to be successful, there would be potential for use of these products on future construction projects with similar slopes and also as a correction or maintenance method on existing slopes in the area.

INSTALLATION

The test area is located on the eastern side of STH 35 in Crawford County, approximately 0.5 miles south of the south junction of STH 35 and STH 82, along the Mississippi River in west central Wisconsin (Figure 1, page 13). The test site is 6.1-9.1 m (20-30 ft.) high, has a ¾:1 talus slope, was constructed in 1992 and was in relatively good condition. The natural slope of the talus material was approximately 1 ¼:1 (horizontal:vertical), but because of space constraints between the bluff and the Mississippi River, the back slopes were left at ¾:1. A control area (no treatment), in excess of 30.5 m (100 ft.) long, was located between the test areas of the two products. The test area covered by the Geoweb product was 207 m^2 while the coverage area for the J.K. Structure was 179 m^2. Representatives from each of the companies were present to ensure proper installation of their respective products.

J.K. Structure

The J.K. Structure, manufactured by J.K. Structure of France, is a 3-dimensional metal skeleton paneling secured to the slope using rebars (Print 1, page 14). The panels measured 1 m x 3 m and were placed at a 45 degree angle across the face of the slope.

End sections, cut at a 45 degree angle from a 2-meter piece , were placed on the sides to create a straight edge. After being placed on the face of the slope, individual panels were fastened together using hog rings. It was learned that it was faster and easier to attach several panels together lengthwise and then carry them up the slope in one piece. After the panels were fastened together along the sides, # 4 rebars (1/2 in. diameter) were slid perpendicularly through and secured to the panels using 1 m to 1.2 m (3.28 to 4.0 ft.) # 8 rebar with a hook welded to the end. These rebars were driven in alongside the perpendicular rebar so that the hooks overlapped the rebar securing it to the slope. A 32 kg (70 lb.) jack hammer with the driving power of 10,350 kPa (1500 psi) was used to drive the stakes. The end sections at the top and bottom of the slope were bent over and pinned to the ground and then covered with top soil to prevent water from getting under the structure.

The J.K. Structure was backfilled using a backhoe with a layer of base course and then a layer of topsoil. The area was seeded and fertilized, then covered with an excelsior erosion mat to keep the seed in place until germination.

Geoweb Cellular Confinement System

Geoweb Cellular Confinement System, manufactured by Presto Products Company, Appleton, WI., is an expandable plastic mesh that is stretched down the face of the slope (Print 11, page 19). The individual cells are 10.16 cm (4 in.) deep and 30.48 (8 in.) across. The Geoweb Confinement System came in 2.4 m x 6.1 m (8 x 20 ft.) sections. The Geoweb was anchored at the top of the slope using pins made from # 8 rebar and 12.5 mm rebars. The 12.5 mm rebar was attached along the top edge of the Geoweb using plastic ties, then anchored down using 0.91 m (3 ft.) pins (# 8 rebar). The Geoweb was then expanded downward and anchored using 33 pins per panel. It was found that a 2.4 m (8 ft.) steel fence post cut in half, with a “T” welded on, held better than the round # 8 rebar in the slope. Originally, the Geoweb supplier intended to use wooden stakes to anchor the Geoweb, but because of the rocky slope, steel pins were used. Because of concerns by the supplier that the Geoweb may not stay in place on the relatively steep

slope, more pins than originally estimated were used. Each pin was attached to the Geoweb using a plastic tie. Adjoining sections of the Geoweb were attached together using plastic ties.

The Geoweb was backfilled with topsoil, seeded and fertilized. Excelsior erosion mat was also placed over the Geoweb to keep the seed in place until germination. The erosion mat was left off the last 2 m (6.5 ft.) of the south end of the Geoweb to see how it performed without the mat.

The control area was an untreated portion of the slope approximately 30.5 m (100 ft.) long between the two products. There was little topsoil and some vegetation covering this area. Topsoil, seed and erosion mat were not placed here during installation.

INSTALLATION RESULTS

Due to slope conditions, pin / stake welding, etc. installation was difficult and time consuming for both products. The estimated cost for the materials and installation was exceeded due to the increased time needed for installation and the added materials. Difficulty driving the stakes was experienced because of the rocky terrain and the angle and height of the slope, which necessitated the use of ladders and a boom to support the jack hammer.

J.K. Structure

Problems associated with the J.K. Structure installation included difficulty driving stakes, handling of the materials, and the learning curve (what was needed and how to do things). The rocky terrain made driving stakes difficult, necessitating the use of a jack hammer. The metal pins furnished were too slim and short, so hooks had to be welded on for added strength. The steep angle and length of the slope made handling the jack hammer difficult, requiring one to two men to operate it and another to hold the stake. Problems associated with handling the material included sharp edges, requiring the workers to wear gloves. The steep angle of the slope required the workers to use ladders to move up and

down the slope. Each section of the J.K. Structure had to be carried up separately (later several sections were attached then carried up the slope). Since this was the first time the workers had used this product, start-up and learning necessary procedures required extra time.

Geoweb

Problems associated with Geoweb installation were similar to those for the J.K. Structure. These included: difficulty driving pins, time, materials and unfamiliarity with the products. The rocky terrain and the steepness and length of the slope made driving the stakes for Geoweb difficult. Because the pins had to be fabricated and the number of pins used for securing the Geoweb was increased beyond the original estimate, installation time was significantly impacted. Not all materials needed were on site.

PERFORMANCE

One month after installation was complete, grass had begun to grow in both the J.K. Structure and the Geoweb. No erosion was noted at either product location or in the untreated control area.

One year after installation, there was limited grass growth and some erosion of the topsoil on both products. The limited grass growth may have been attributed to late seeding, winter kill and erosion of the topsoil. Some of the erosion mat was still present. The control area, which had been in place for two years, had more plant growth than either the J.K. Structure or the Geoweb.

An early 1996 review of the test installation by District 5 personnel showed both test sections to be performing better than the control section with less erosion, however grass growth was still limited.

The J.K. Structure and Geoweb installations were surveyed on June 27, 1996 by staff from the Geotechnical and Pavement Research Sections. The following observations were made:

Vegetation:

J.K. Structure (print 6, page16)

75-80% of this area had no vegetation. There were some areas of crown vetch, a few rye and other grasses and various weeds growing.

Geoweb (print 14, page 20)

80-85% of this area had no vegetation. There were some areas of crown vetch, a few rye and other grasses and various weeds growing.

Control Section (print 20, page 23)

Appeared to be 70% covered with vegetation, but the vegetation consisted mainly of sweet clover which is tall and coarse, so actual ground cover was less because individual plants are spaced farther apart. There was also some crown vetch and other grasses growing.

Erosion:

Both the J.K. Structure and the Geoweb had erosion of the topsoil, possibly due to the lack of vegetation. The area of Geoweb with no erosion mat showed more erosion of topsoil than that with the erosion mat. Most of the straw erosion mat was gone, leaving the netting. There was no apparent erosion of the underlying slope materials in these two areas.

The control section had some areas of erosion. Rocks (8-10" and smaller) and soil had accumulated at the bottom of the slope in these areas. The locations of these areas as measured from the south end to the control area were:

+30' - mid-slope to bottom of slope

+50-60' - mid-slope to bottom of slope

+95-100' - top of slope to bottom of slope, crown vetch at bottom of slope

+120' - mid-slope to bottom of slope

On the untreated area at the north end of the J.K. Structure, an area of erosion was noted. This erosion appeared to be approximately 1.0 ft. deep and stopped at the interface with the J.K. Structure.

Even though no major erosion or slope failures had occurred on either the J.K. Structure or the Geoweb or the Control Section after 1.5 years, it appeared that the J.K. Structure and the Geoweb prevented small, localized areas of erosion, however there was not a significant difference between the test products and the control.

2.5 Year Inspection (April 15, 1997)

Vegetation:

There was little evidence of vegetative growth on both products and the control, perhaps due to the inspection taking place early in the year.

Erosion:

Most of the straw erosion mat was gone from the J.K. Structure and the Geoweb areas, leaving the netting. There was no apparent erosion of the underlying slope material in the J.K. Structure and Geoweb areas.

J.K. Structure (print 21, page 24)

The top 10 - 15 ft. of the slope showed some loss (< 25%) of the topsoil. The rest of the J.K. Structure appeared to be holding the topsoil.

Geoweb (print 16, page 21)

Loss of topsoil from the Geoweb cells was noted throughout the entire Geoweb area. Approximately 50% of the topsoil from the individual cells was lost, mainly on the top half of the slope. The section of Geoweb without the erosion mat had a loss of 50 - 75% of the topsoil. There was an isolated area with 100% loss of topsoil. It was also noted that there were areas where the topsoil appeared to have eroded from underneath.

Control (print 21, page 24)

Areas of erosion were observed in the control section. The locations of these areas as measured from the south end of the control area are:

+0 - 5 ft. – small areas of erosion, mid-slope to bottom of slope.

+5 - 25 ft. – no erosion.

+25 - 78 ft. – erosion from mid-slope (10-12' from bottom of slope) to bottom of slope.

+78 - 100 ft. – erosion started 10' from top of slope to bottom of slope. Bottom of slope had been cleaned out with yumbo, possibly earlier that spring. At +95 - 100 ft., an area of the erosion was approximately 2 ft. deep.

+100 ft. to end of control – Some sloughing of slope material had occurred.

On the untreated area at the north end of the J.K. Structure, an area of erosion was noted. This erosion appeared to be approximately 2 ft. deep and stopped at the interface with the J.K. Structure. Material at the bottom of the slope had been cleaned out.

3 Year Inspection (September 3, 1997)

There appeared to be little change from the April 15, 1997 inspection. The following observations were made:

Vegetation:

Some sparse vegetative (crown vetch and sweet clover) growth was observed on the J.K. Structure, the Geoweb and the Control Section.

Erosion:

There was no apparent new erosion of the underlying slope material in the J.K. Structure and Geoweb areas.

J.K. Structure, Geoweb and the Control Section:

No additional erosion, from that noted in the April inspection, was observed.

As noted in the 2.5 year inspection, on the untreated area at the north end of the J.K. Structure, an area of erosion was noted. This erosion still appeared to be approximately 2 ft. deep and stopped at the interface with the J.K. Structure. No new material was observed at the bottom of the slope.

4 Year Inspection (June 17, 1998)

More soil build up was observed with both products vs. the untreated control area and the untreated area to the north of the J.K. Structure. The majority of the vegetation was crown vetch.

J.K. Structure: (print 9, page 18)

Approximately 50% covered with vegetation.

Geoweb: (print 17, page 22)

Approximately 50-60% covered with vegetation.

Control: (print 22, page 24)

Approximately 30-40% covered with vegetation.

5 Year Inspection (August, 1999)

J.K. Structure: (print 10, page 18)

Vegetation cover, mostly crown vetch, was approximately 70% for this area, while approximately 30% of the area was sparse and partly washed out. An accumulation of topsoil was noted at the base of the slope, however the slope still had topsoil on most of it, as exposed rock was mostly non-existent. The "washed out" area still had topsoil in place. A couple of small trees have started growing.

The netting from the erosion mat was still in place, possibly helping "hold" everything in place (topsoil, vegetation, rocks). It was noted that the untreated area to the north of this test site had more rocks accumulate at the base of the slope.

Geoweb (print 18, page 22)

Approximately 90% of this area had some form of vegetative cover, mostly crown vetch, sweet clover and fox tail. Although it was about 90% covered with vegetation, the cover was quite sparse upon closer inspection. A couple of washed out areas were observed exposing bare rock. Only one to two 8-10" rocks were observed at the base of the slope, much less than the control area and also less than the J.K. Structure. The cellular webbing was observed to be quite distorted, probably from gravity trying to "pull" the soil-filled cells down the slope. It was also noted that the cells still containing topsoil had denser vegetative growth than the cells which were bare and void of topsoil due to erosion etc. A lot of topsoil was still present in the cells.

Control (print 24, page 25)

The control area had approximately 70% cover, mostly crown vetch, sweet clover and fox tail. The base of the control area had an accumulation of small rocks (6-15" in diameter) at the base of the slope. The accumulation of rocks at the base of the slope was largely absent from the J.K. Structure and the Geoweb areas.

COSTS

The cost of installation of these two products was much more than anticipated due to increased labor costs and added materials: pins, etc. The following table outlines the quantities and costs of the two products and materials for installation.

	J.K. Structure	Geoweb
Product	180 m^2 (215 yd^2) = $7912.20	280 m^2 (249 yd^2) + 550 3' # 8 rebars = $3692.50
Topsoil	30.5 m^3 (40 yd^3) @ $1.50 = $60.00	49.5 m^3 (65 yd^3) @ $1.50 = $97.50
Labor	$5,092.35	$5,092.35
Seed & Fertilizer	$245.47	$245.47
Longshot Trucking	$686.00	$686.00
Excelsior & Staples	$202.00	$262.00
Equipment	$4,221.68	$4,221.68
3' Steel Posts	± 250 @ $0.90 = $225.00	$118.95
1/2" rebar	235 m (776 ft.) @ $0.18 = $139.68	80 m (264 ft.) @ $0.18 = $47.52
Hog Rings	± 3000 = $40.50	
Small Mustang Loader	$91.00	
Plastic Ties		$529.91
TOTAL:	$18,915.88	$14,993.88
COST / M^2:	$105.09	$72.09

RESULTS / CONCLUSIONS

J.K. Structure

Overall, the performance of the J.K. Structure was favorable, it did what it was supposed to do - stabilize the slope. As evidence, the untreated area to the north of the J.K. Structure experienced an area of erosion / wash out that stopped with the interface of the J.K. Structure. It appeared that this resulted in the base of the slope being littered with small rocks (6-15" in diameter). It seems that the erosion caused a small wash out area, in turn causing the rocks to "slip" from the face of the slope and tumble to the bottom of the slope. The control area (no treatment) to the south of the J.K. Structure was also strewn with an accumulation of rocks 6-15" in diameter. After five years the base of the J.K. Structure was largely void of these rocks, no major slope failures had occurred and erosion was limited to small localized areas. In addition, the product itself was still in good condition and holding up to environmental elements.

Problems associated with the J.K. Structure installation included difficulty driving stakes, handling of the materials, and the learning curve (what was needed and how to do things). The rocky terrain made driving stakes difficult, necessitating the use of a jack hammer.

The metal pins furnished were too slim and short, so hooks had to be welded on for added strength. The steep angle and length of the slope made handling the jack hammer difficult, requiring one to two men to operate it and another to hold the stake. The steep angle of the slope required the workers to use ladders to move up and down the slope. Each section of the J.K. Structure had to be carried up separately (later several sections were attached then carried up the slope). Overall, installation was quite laborious and time consuming requiring the use of a boom, a backhoe, ladders and a jack hammer to drive the anchors into the rocky terrain.

Geoweb

Overall, the performance of the Geoweb Cellular Confinement System was also favorable. After five years there were no major slope failures, the product was still in relatively good shape and the base was largely void of any significant accumulation of rocks that were dislodged due to erosion. Only a couple of small wash out areas were observed, exposing bare rock. The adjacent control area experienced an area of erosion / wash out and a resulting accumulation of rocks at the base of the slope.

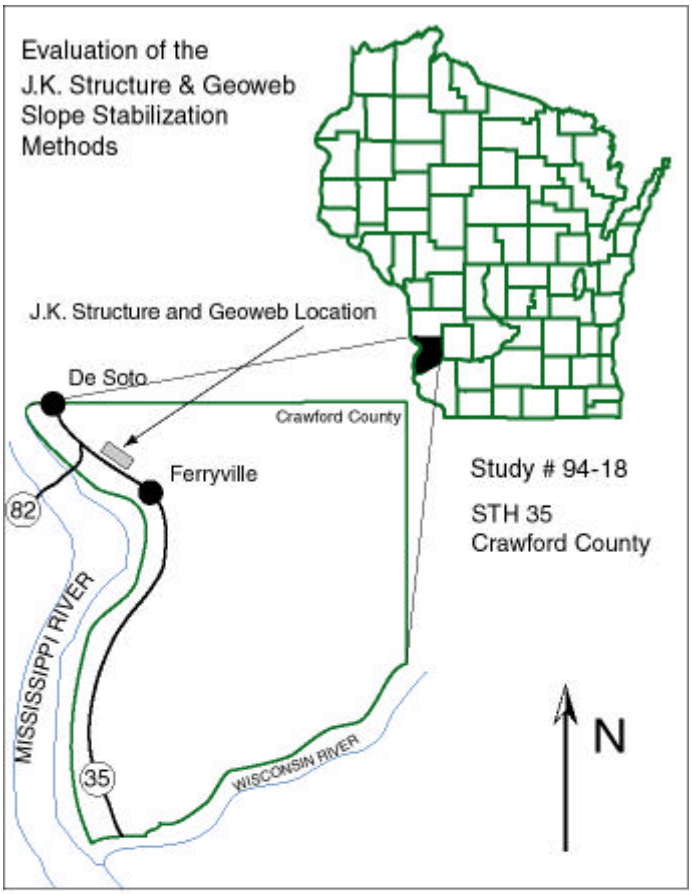
Problems associated with Geoweb installation were similar to those for the J.K. Structure. These included: difficulty driving pins, time, materials and unfamiliarity with the product. The rocky terrain and the steepness and length of the slope made driving the stakes for Geoweb difficult. Because the pins had to be fabricated and the number of pins used for securing the Geoweb was increased beyond the original estimate, installation time was significantly impacted.

Grass cover never really got established on either product. This is probably due to the late seeding in the fall of 1994 during initial installation. The grass never really got a chance to grow before the onset of winter. No follow-up seeding was carried out in the following spring.

RECOMMENDATIONS

Both products performed favorably, preventing major slope failures and limiting erosion to small localized areas. Performance was rated as better than the control area (no treatment) for both products. However, the difference was not real significant in this particular application, so the return was minimal when compared to the costs of the products and the difficulty of installation. The recommendation is that these products not be approved for widespread use by WisDOT, however, these products could be considered for use on a case by case basis where major slope failures are common.

Figure 1. Location of slope stabilization test products.



Print 1. Close-up view of the J.K. Structure.

Print 2. J.K. Structure in background. Foreground shows anchoring stakes with a “T” welded on the end for securing the structure down.

Print 3. Installation of the J.K. Structure showing the use of ladders and the boom used to hold the jack hammer.

Print 4. Use of a backhoe was needed to “fill” the J.K. Structure with topsoil.

Print 5. Untreated Control Area between the J.K. Structure on the left and the Geoweb on the right. Notice use of an erosion mat for both products.

Print 6. Vegetation on J.K. Structure June 27, 1996, almost two years after installation.

Print 7. J.K. Structure, October 30, 1996, two years after installation.

Print 8. View of the washed out area to the north of the J.K. Structure. Notice that the washed out area stops at the interface with the J.K. Structure.

Print 9. View of the vegetation on the J.K. Structure, June 17, 1998.

Print 10. View of the vegetation on the J.K. Structure, August, 1999. Notice the washed out area to the north (left) of the J.K. Structure.

Print 11. Close-up view of the Geoweb Cellular Confinement System.

Print 12. Sawing the rebar anchors flush with the Geoweb.

Print 13. Geoweb covered with erosion mat, untreated area of Geoweb (no mat) to right.

Print 14. View of vegetation on Geoweb, June 27, 1996, almost two years after installation.

Print 15. Geoweb, October 30, 1996, two years after installation.

Print 16. Geoweb, April 15, 1997.

Print 17. Geoweb, June 17, 1998 showing sparse vegetation cover.

Print 18. Geoweb, August, 1999, five years after installation.

Print 19. Geoweb (in foreground), control and J.K. Structure, September 25, 1995.

Print 20. View of vegetation on J.K. Structure to the left, control section right 2/3^{rds} of photo, June 27, 1996.

Print 21. Geoweb, Control and J.K. Structure, April 15, 1997.

Print 22. Control Section, June 17, 1998.

Print 23. J.K. Structure (left half), and Control Section (right half), August, 1999.

Print 24. Geoweb, Control and J.K. Structure, August, 1999, five years after installation.